SWRHL-63r

AGRONOMIC ASPECTS OF THE EXPERIMENTAL DAIRY FARM
JANUARY 1966 - DECEMBER 1968

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INTRODUCTION:

The United States Atomic Energy Commission (AEC) on July 1, 1963, awarded a contract to the Southwestern Radiological Health Laboratory (SWRHL), U. S. Public Health Service (USPHS) to study the transport of radioiodine through the environment to man. The problem was to determine the passage of radioiodine through the air-forage-cow-milk-man system. To initiate this program Bioenvironmental Research (BER) was established within SWRHL for the purpose of developing a field and laboratory research program to answer the questions posed by the AEC.

An experimental farm facility was required to study radioiodine passage through the food chain under field conditions. Criteria for the farm site were detailed and the search for a specific location on the Nevada Test Site (NTS) was begun in 1963. The criteria are covered in SWRHL-36r "Status of the Nevada Test Site Experimental Farm" by Richard L. Douglas. The site selected is located in Area 15 of the NTS and is 110 miles north of SWRHL in Las Vegas. (See Figure 1.)

The farm site is a gently sloping alluvial fan in a high desert valley surrounded by mountains opening to the south. The average elevation is approximately 4500 feet and the average land slope is 2-4 percent to the southeast. The soil is a gravelly, sandy loam with cobbles and stones scattered throughout. It contains little organic matter and has an average pH of 8.5.

Design and construction of the facility began in the spring of 1964. The land was cleared, the reservoir constructed, and the first crop was planted that fall. The facility was completed and the dairy cows were moved to the new dairy barn during the spring of 1966. A

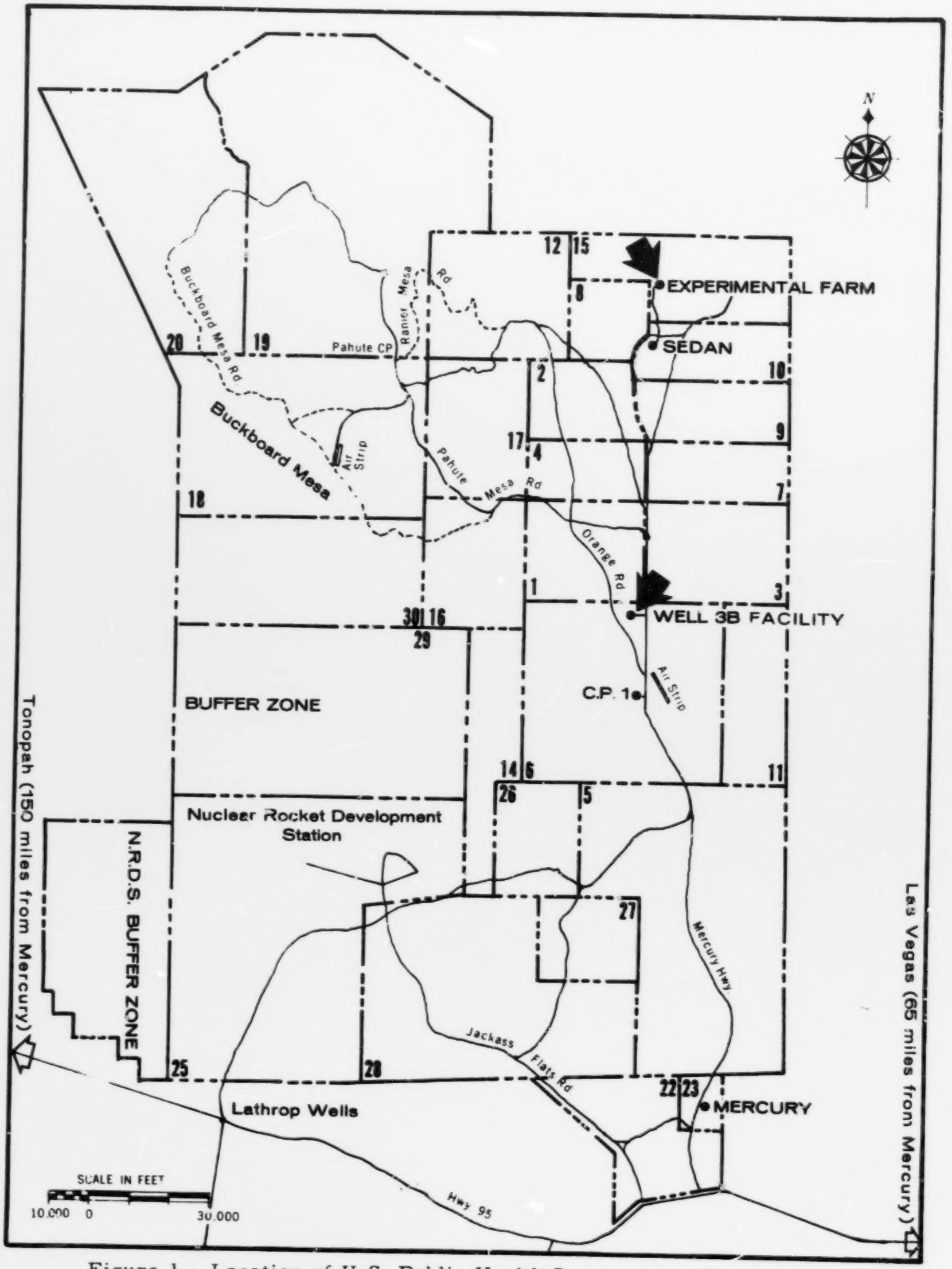

Figure 1. Location of U.S. Public Health Service facilities on the Nevada Test Site.

diagrammatic representation of the facilities as of December 31, 1968, is shown in Figure 2.

The crop area consists of 16 acres which are divided into 17 plots or lands by the irrigation laterals. Each of the two end lands has an area of approximately one-half acre. The remaining 15 lands each contain one acre. As of December 1968, the crop lands were planted to 11-1/2 acres of alfalfa, 2 acres of mixed grasses, and 2-1/2 acres of rye grain. (Figure 3 shows the crop locations.)

The agronomic procedures practiced on the experimental farm follow recommended practices or duplicate the actual practices used by commercial crop producers of the Southern Nevada, Southern Utah, Western Arizona, and Southern California desert areas. Several varieties of alfalfa, rye, oats, barley, wheat, and Sudangrass have been planted to determine their adaptibility and yields. On the basis of these crop trials, rye grain has been selected for early green chop and either Lahontan or N.K.-1019 alfalfa for late green chop and for hay production.

The Farm Support Section (FSS) of BER is charged with the responsibility of maintaining the experimental dairy farm. The agronomic practices from January 1, 1966 through December 31, 1968, are covered in this report.

FERTILIZATION PROGRAM:

As is generally true under desert conditions, the soils of the Area 15 Farm are alkaline (pH 8.5) and are deficient in two essential plant nutrients -- nitrogen and phosphorous. The leaching effect of irrigation water percolating through the coarse sandy loam soils accentuates these deficiencies; therefore, a heavy fertilization program is required.

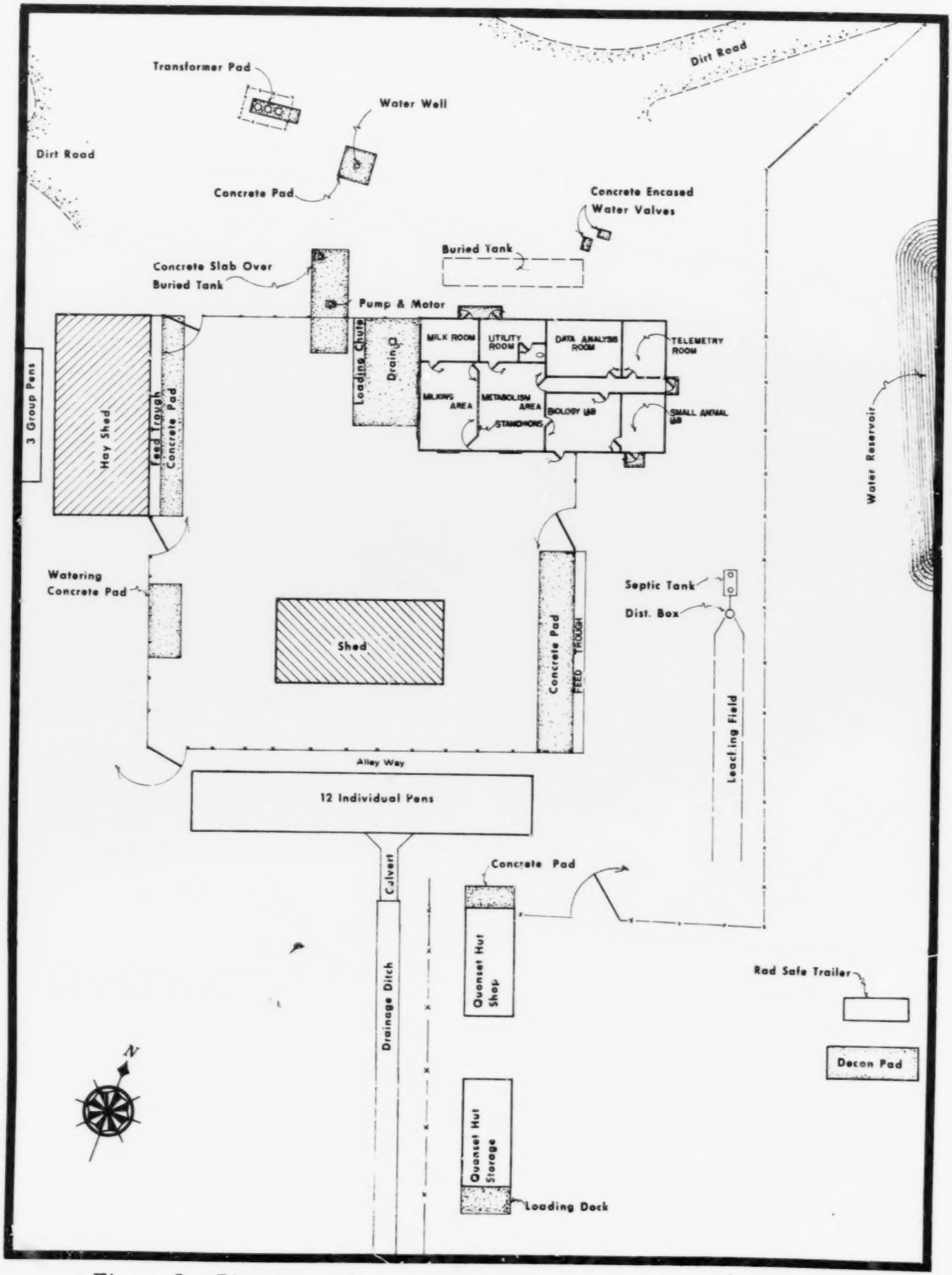

Figure 2. Diagrammatic representation of the facilities.

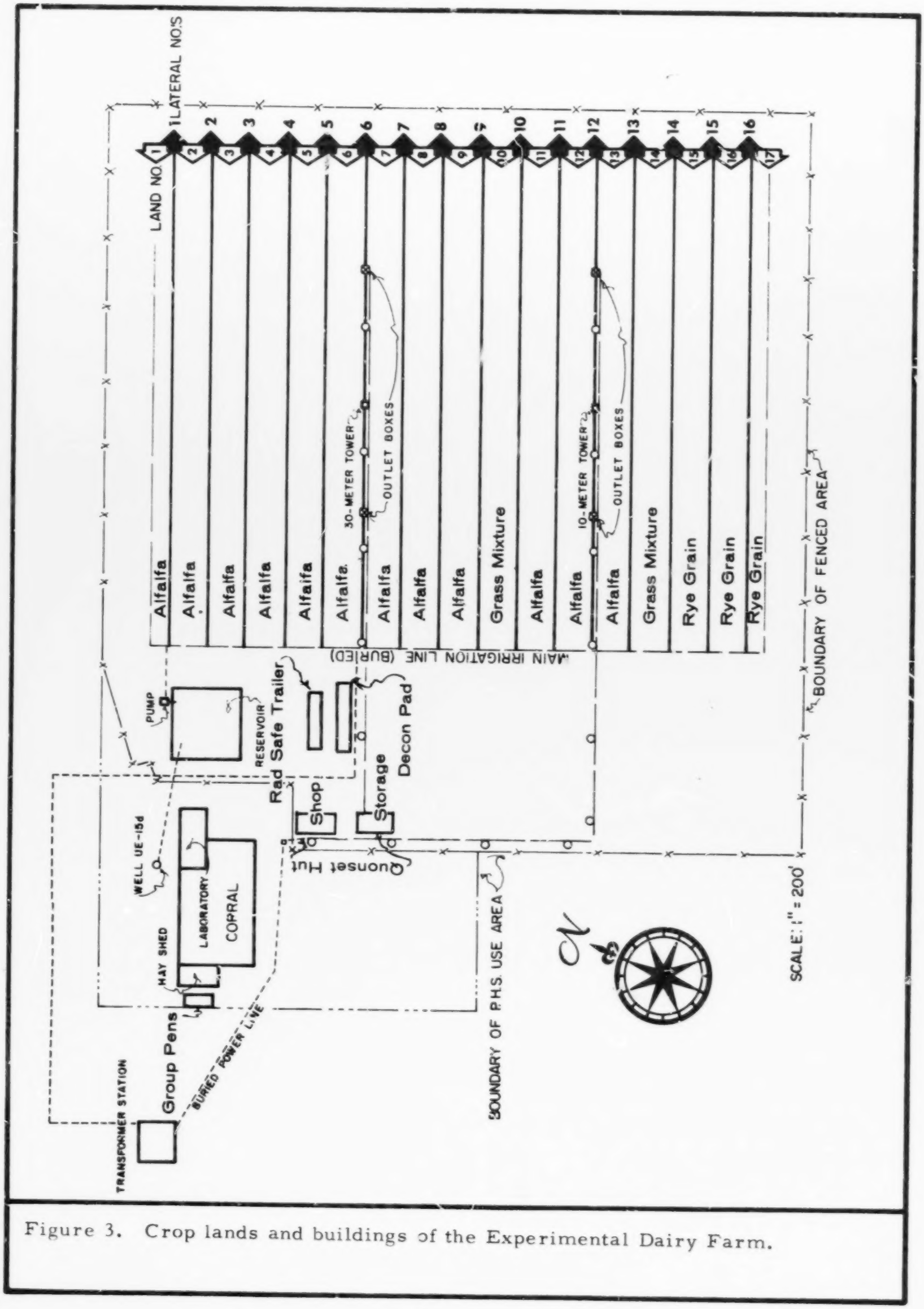

Figure 3. Crop lands and buildings of the Experimental Dairy Farm.

In order to lower the pH of the soils, 1,000 pounds of flowers of sulphur were applied to each land in March of 1967. Through the judicious application of fertilizer and liberal irrigation we are able to produce high quality crops with satisfactory yields.

Fertilizers commonly used are: Ammonium sulfate (21-0-0)[1], treble superphosphate (0-45-0)[1], and potash (0-0-52)[1]. Ammonium sulfate was selected as the nitrogen source because the sulfate ion helps to lower or maintain the pH of the soil and the compound breaks down slowly so nitrogen is available to plants for a longer period.

The above listed fertilizers are granular in nature and are mechanically applied to each land individually. Phosphorus is applied during the growing season when indicated by crop needs or prior to planting. (See Appendix I for dates and amounts applied.) Occasionally, crops may suffer a deficiency of some of the micro-nutrients, i.e., iron, zinc, etc. These are supplied to the crops by metering them into the irrigation water with the Dragon Fertilizer® Injector.

IRRIGATION PROGRAM:

As the annual precipation is only 4.5 inches, supplemental water is required for forage crop production. The irrigation well, reservoir, and sprinkler system are described in SWRHL-36r and remain unchanged except that laterals 10 through 16 were buried in the fall of 1966 in order to facilitate farming practices.

The type of crop grown, stage of development of the plant, amount of soil moisture, and weather conditions are the determining factors in the frequency and quantity of irrigation water required for each land. The alfalfa has developed a deep root system and requires an extended irrigation period in order that the water can penetrate to the lower root zone, however, less frequent irrigations are necessary as the

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[1]This formula expresses the percentage by weight of nitrogen, phosphous, and potassium, respectively, which are supplied by the fertilizer.

plants are able to draw moisture from the greater depth. After crops are planted, frequent and light irrigations are necessary to insure seedling survival and growth of young plants. The grasses and small grains require less frequent irrigations after they are established. The small grains require more frequent irrigations than the alfalfa or grasses.

The peak irrigation season extends from May through October (see Figure 4). Approximately six acre feet* of water is applied annually to each land. This varies somewhat with the type of crop grown. Appendix II lists the monthly irrigation of each land.

As the flow rate of the irrigation well is not sufficient for direct application to the crops, a million-gallon storage reservoir was constructed (described in SWRHL-36r). Initially this reservoir leaked badly but after the application of bentonite in 1964, and grouting in the spring of 1965, the loss rate decreased. During the fall of 1967, there was a substantial increase in the seepage rate. An investigation was made to determine various ways of decreasing the seepage loss. (See Appendix III.) A chemical soil sealant, Soil Sealer 13 was chosen. One thousand gallons of this material was applied to the reservoir on March 27, 1968, by Seepage Control, Inc. of Phoenix, Arizona. A follow-up treatment of 400 gallons of Soil Sealer 13 was applied by Farm Support Section personnel on April 5, 1968. The Soil Sealer 13 has descreased our water loss from 46,000 gallons per day to approximately 22,000 gallons per day. A significant portion of this continuing loss is due to evaporation.

AGRONOMIC SUMMARY - 1966:

During the winter of 1965, Lands 14-17 were disced and left fallow. In June 1966, Lands 14 and 16 were planted with Piper Sudangrass, (Sorghum vulgare var sudanense). Lands 15 and 17 were planted with

*Acre foot = 325,850 gallons.

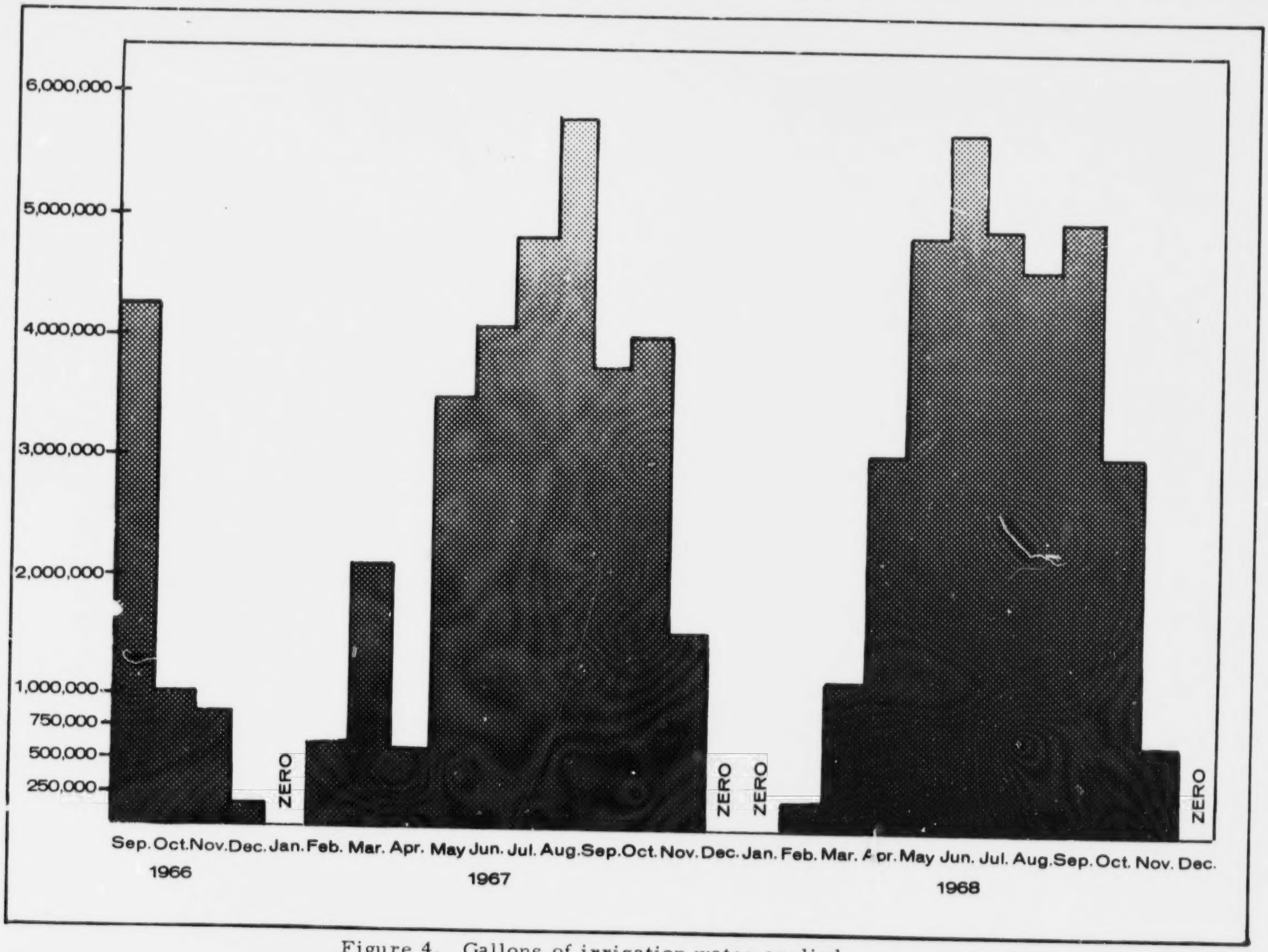

Figure 4. Gallons of irrigation water applied.

Northrup King Trudan II (variety of hybrid Sudangrass). The Sudangrasses received approximately 100 pounds of nitrogen during the growing season. Despite the heavy fertilization, chlorosis (yellowing) or stunted growth occurred. Investigation revealed that this was caused by a deficiency of iron, which is fixed into a biologically unavailable form by the action of the carbonates found in the soil and irrigation water. (See Appendix VII.) Since experience has shown that Sudangrass is extremely sensitive to iron deficiency and that this deficiency becomes progressive with time, it was decided to eliminate Sudan as a standard forage crop for the experimental herd.

Harvesting of rye green chop began in May. Green chop was harvested until October 14, when the first killing frost of the season occurred. During this harvesting period 60 tons of rye grain, alfalfa, and Sudangrass were utilized for green chop. (See Figure 5 and Appendix IV.) Appendix V lists the total production of crop per land. Average production was 4.67 ton rye/acre, 3.4 ton Sudan/acre, and 4.1 ton alfalfa/acre.

No hay was harvested during 1965 or 1966 as haying equipment was not purchased until the spring of 1967. (See Appendix VI.)

During September 1966, Lands 10 through 17 were subsoiled. Rocks brought to the surface by the subsoiler were removed by BER personnel. The rocks are a continuing problem as they are brought to the surface during any tilling operation and must be removed by hand. This problem will never be completely eliminated.

The same month, Lands 10 and 14 were planted with a mixture of alfalfa (Medicago sativa) Lahontan variety, tall fescue (Festuca arundinacea) Goar variety, Orchard grass (Dactylis glomerata), and smooth brome (Bromus inermis). Land 15 was planted with barley (Hordeum vulgare) Alpine variety, and Land 16 was planted with wheat (Triticum aestivum) Moro variety.

Lands 11 and 12 were planted to rye grain (Secale cereale) during October. Lands 13 and 17 were left fallow during the fall, winter, and spring of 1966 and 1967.

AGRONOMIC SUMMARY - 1967:

Green chop was harvested from April 6 through October 19, at which time frost damage terminated harvesting. Alfalfa (May 30 - October 19) and small grains (April 6 - May 30) were utilized for green chop with alfalfa providing the larger tonnage of the green chop. A total of 80 ton of green chop was harvested during this period. (See Figure 5 and Appendices IV and V.) Average production of green chop was 6 ton per acre for the rye and 7.3 ton per acre for the alfalfa.

Wheat hay was baled on May 12. The first alfalfa hay was baled on June 23, and was rated as Grade U. S. Number 1 Leafy. All the hay produced has been Grade U. S. Number 1 Leafy or Extra Leafy Hay. Four cuttings of hay were harvested, one per month in June, July, August, and September. A total of 1,121 bales (60 pounds each) was produced. This was about 33-1/2 ton (4.1 ton per acre) of alfalfa hay. (See Figure 5 and Appendices IV and V.)

Land 11 was planted to alfalfa (Medicago sativa) Lahontan variety, on August 2. Lands 12 and 13 were planted to alfalfa (Medicago sativa) Northrup King 10-19 variety on the same date.

Lands 15, 16, and 17 were planted to rye grain (Secale cereale) Oregon common variety on October 13, 1967. Prior to and after planting, several ton of rocks were removed from the field.

As explained on page 9, Sudangrass was eliminated as a regular forage crop because of severe chlorosis. However, it was decided to use Land 17 as an experimental plot in order to determine the effectiveness of the agent, Sequestern 138®[1] (iron chelate). This compound was applied with the seeds at the time of planting (June 27, 1967) and again as a foliar spray after the first cutting (August 18, 1967). The

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[1]Geigy Agriculture Chemicals, Ardsley, New York.

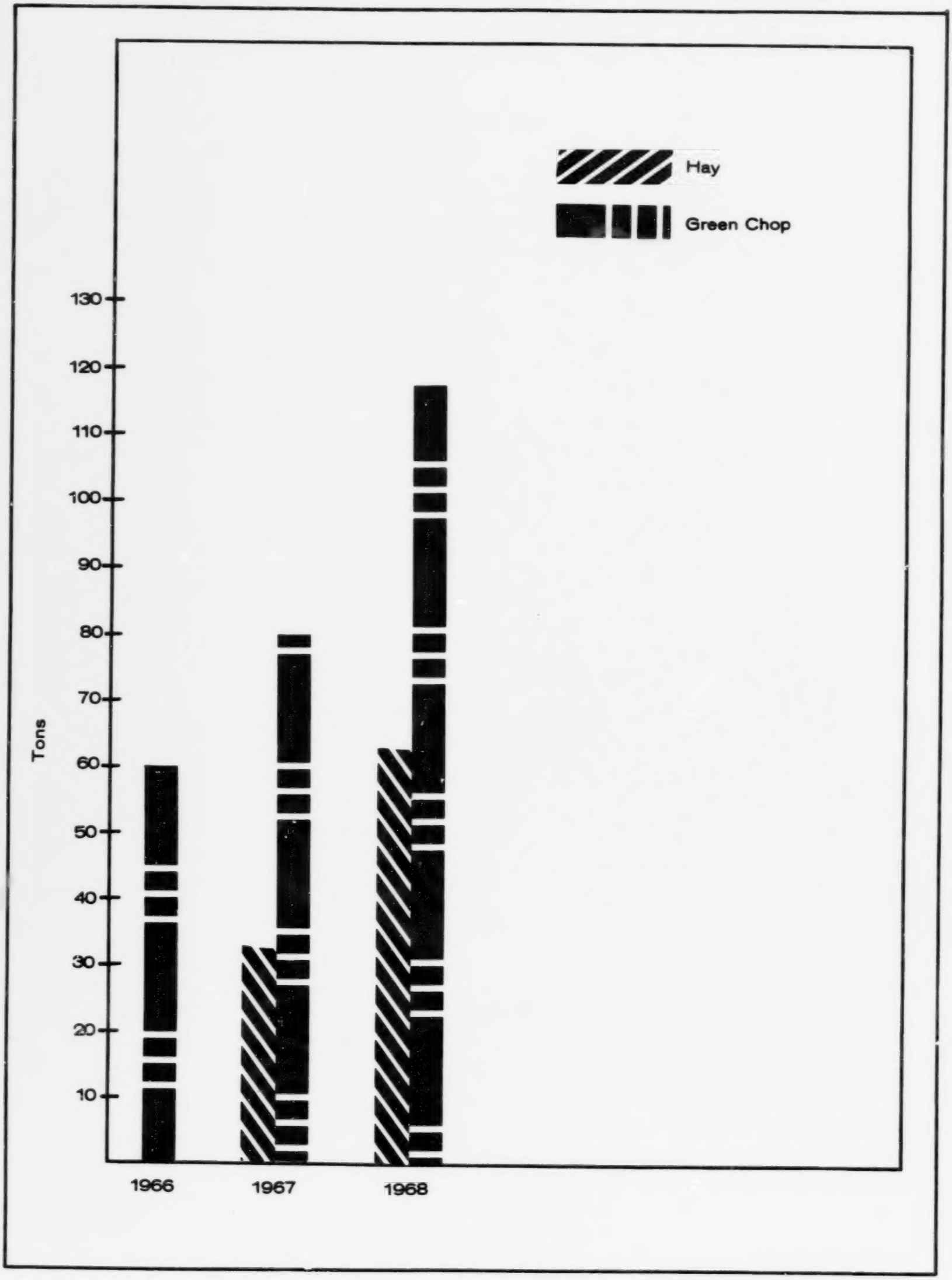

Figure 5. Forage production.

plants showed no response to either treatment and continued to be chlorotic. (See Appendix VII.)

Another problem which required control measures during the season was a large rodent population. Perhaps, because of the presence of readily available feed and/or because of protection (fence) from their natural predators, the resident population of gophers increased during the fall and winter of 1966. The mounds at their burrow entrances protruded several inches above the ground level and interfered with green chop harvesting. Control methods were investigated and Mr. Bill S. Meck of the U. S. Fish and Wildlife Service, Ely, Nevada, was contacted. He brought a rodent extermination machine into the crop area of the farm on March 6. The torpedo shaped point penetrated into the soil approximately 12 inches and as the machine moved a tunnel was formed and poisoned grain (strychnine) was metered into the run. Follow-up treatments with poisoned grain placed in the runs resulted in a decreased gopher population. A rodent control program is now followed, so that when any activity is noted, poisoned grain is placed in the runs.

AGRONOMIC SUMMARY - 1968:

A good stand of rye grain (Secale cereale) Oregon common variety planted the previous fall was utilized for green chop during April and May. The yield was heavy and regrowth rapid enough to allow three cuttings of the rye. Harvesting of green chop began on April 9 and continued until the killing freeze of November 15. The total production of green chop was 117 ton with the majority of the green chop being alfalfa. (See Figure 5 and Appendices V and VI.) Production of rye green chop averaged 10.4 ton per acre and alfalfa green chop averaged 7.9 ton per acre.

In the spring of 1968, a severe infestation of aphids was responsible for the loss of one cutting of alfalfa. Each acre of alfalfa was sprayed with 16 ounces of Malathion, applied in 25 gallons of water.

A few days later the alfalfa was clipped and resprayed with malathion at the same rate. This treatment was effective and there were no other insect problems during the remainder of the season. The production of alfalfa hay was 63 ton or 5.8 ton per acre. (See Figure 5 and Appendices V and VI.)

The east half of Land 13 was planted with Piper Sudangrass on July 31, in preparation for a field study. The north half of Land 15 was planted on July 29, with Trudan II Sudangrass for the feeding of the cows prior to the project. On September 27, Land 13 was replanted to alfalfa.

On October 11, 1968, Land 15 was planted with rye, (Secale cereale) Balboa variety, Land 16 planted with rye (Secale cereale) Elbon variety, and Land 17 with rye (Secale cereale) Oregon common variety.

Rye grain has been selected as the small grain. It has been observed to be winter hardy, produces early green chop, and the regrowth is rapid, which allows three harvests a season. By utilizing the rye for early green chop most of the first cuttings of alfalfa can be harvested as baled hay.

AGRONOMIC COMPARISONS WITH ADJACENT AREAS:

As stated previously, the procedures practiced on the experimental farm follow recommended practices or duplicate actual practices used by commercial farmers of this general geographic area. Direct comparisons of yield, fertilization needs, and water requirements are difficult as the experimental farm is isolated and not part of a specific farming area. Each area has its unique characteristics that influence the agronomic practices and determine, to a great extent, the yield. Some of these characteristics are fertility, soil pH, soil type and depth, organic matter content, altitude and length of growing season, amount of precipitation, and quality of irrigation water, etc.

A 1964 survey of the Pahrump, Nevada, farming community (70 miles south of the farm) revealed that the average annual production of alfalfa hay from established fields was eight ton per acre produced in six cuttings. Area 15 production in 1968 was 5.8 ton per acre produced in four cuttings plus 7.9 ton of alfalfa green chop per acre.

The average alfalfa hay production in Maricopa County, Arizona, (approximately 400 miles southeast) is 5 ton per acre with a range of 3-12 ton from five cuttings a year. Average irrigation required in Maricopa County was 6.2 acre feet per acre.

The University of Nevada Extension Service estimates that alfalfa grown in Southern Nevada requires 7.5 acre feet of water per acre per year. Irrigation at the experimental farm has averaged 6.3 acre feet per acre per year on the alfalfa and 3.5 acre feet per acre per year for the small grain.

The average production of rye green chop from 1956-1961 on the University of Nevada Agricultural Experimental Station, Logandale, Nevada, (100 miles southeast) was 4.4 ton per acre dry weight or approximately 9 ton per acre wet weight. Area 15 production has averaged 7 ton per acre and exceeded 10 ton per acre in 1968.

FARM PARTICIPATION IN ^{131}I EXPERIMENTS:

There were five ^{131}I controlled release experiments conducted at the farm between January 1966 and December 1968. Three of these experiments consisted of dry aerosols of diatomaceous earth tagged with ^{131}I which was generated over growing forages. One, Project Rainout, was an ^{131}I solution which was sprayed on a forage plot and one, Project MICE, was a release of molecular $^{131}I_2$.

Under proper meterological conditions, the aerosols or solutions are released so that the selected forage plot is contaminated. The plot is then harvested either as green chop or as baled hay and fed to the

dairy cows in a prescribed manner. Table 1 lists the experiments conducted thus far. Details and results of these experiments are related in the following reports which have been published or are now being prepared for publication:

Experiment	SWRHL No.	Title	Authors
Alfalfa	SWRHL-42r	^{131}I Dairy Cow Uptake Studies Using a Two Micron Count Median Diameter Synthetic Dry Aerosol	Stanley, Black, and Barth
Rainout	SWRHL-43r	^{131}I Transport Through the Air-Forage-Cow-Milk System Using an Aerosol Mist	Douglas, Black, and Barth
SIP	SWRHL-39r	^{131}I Dairy Cow Uptake Study Using a Submicrometer Synthetic Dry Aerosol	Mason, Black, and Barth
MICE	SWRHL-85r	Radioiodine Transport Through the Air-Forage-Cow-Milk System Using a Gaseous $^{131}I_2$ Contaminant	Douglas and Black
HARE	SWRHL-61r	Cow Milk ^{131}I Levels Following Ingestion of Synthetically Contaminated Alfalfa or Sudan	Black, Stanley, and Barth

Table 1. Controlled ^{131}I Release Experiments

Name of Experiment	Date	Type of ^{131}I Release	Type of Forage Contaminated
Alfalfa	21-29 Jun 66	Diatomaceous earth aerosol	Alfalfa-Oats mixture, for green chop*
Rainout	29 Sep-6 Oct 66	Hydrosol	Alfalfa for green chop**
SIP	6-13 Jun 67	Diatomaceous earth aerosol	Alfalfa for green chop
MICE	22-29 Sep 67	Gaseous	Alfalfa for green chop and for hay
HARE	18-25 Sep 68	Diatomaceous earth aerosol	Alfalfa and Sudangrass for green chop

*Loosely stacked alfalfa hay and stacked green chop were utilized on Project Alfalfa; after this project it was decided to discontinue the stacked green chop as the feed heated rapidly, spoiled, and lost its palatability so the cows refused to eat it after two or three days.

**Loosely stacked alfalfa hay was also utilized on Project Rainout.

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APPENDIX I. Tabulation of Fertilizer applied to each land (January 1966 - December 1968)

Fertilizer is expressed in pounds of actual nutrients applied, i.e., N represents nitrogen, P_2O_5 represents phosphorus, K_2O represents potassium and S represents sulfur.

Date	Lands								
	1	2	3	4	5	6	7	8	9
10 Feb 66	90#P_2O_5	90#P_2O_5	90#P_2O_5	90#P_2O_5	90#P_2O_5	90#P_2O_5	90#P_2O_5	90#P_2O_5	90#P_2O_5
21 Apr 66	50#N 100#P_2O_5	50#N 100#P_2O_5							
19 Jul 66	90#P_2O_5 45#N	90#P_2O_5 45#N	90#P_2O_5 45#N	90#P_2O_5 45#N					
25 Jul 66					90#P_2O_5 45#N	90#P_2O_5 45#N	90#P_2O_5 45#N	90#P_2O_5 45#N	90#P_2O_5 45#N
10 Mar 67	27#P_2O_5	54#P_2O_5	54#P_2O_5	54#P_2O_5	54#P_2O_5 16#N	54#P_2O_5 16#N	54#P_2O_5 16#N	54#P_2O_5 16#N	54#P_2O_5 16#N
24 Mar 67	500#S	1000#S	1000#S	1000#S	1000#S	1000#S	1000#S	1000#S	1000#S

APPENDIX I. Tabulation of Fertilizer applied to each land (January 1966 - December 1968 cont'd)

Date	Lands								
	1	2	3	4	5	6	7	8	9
11 Mar 68	72#P_2O_5								
14 Mar 68		162#P_2O_5	162#P_2O_5	162#P_2O_5	162#P_2O_5	162#P_2O_5	162#P_2O_5	162#P_2O_5	162#P_2O_5
21 Jun 68		16#N 108#P_2O_5							
12 Jul 68				78#K_2O				78#K_2O	

APPENDIX I. Tabulation of Fertilizer applied to each land (January 1966 - December 1968 cont'd)

Date	Lands							
	10	11	12	13	14	15	16	17
12 Feb 66	60#N	60#N	60#N	60#N	100#N	100#N	100#N	100#N
20 Jul 66					27#N	27#N		
18 Sep 66	72#N	72#N	72#N		72#N			
27 Oct 66	36#P_2O_5	36#P_2O_5	36#P_2O_5		36#P_2O_5			
22 Feb 67	50#N	50#N	50#N		50#N	50#N	50#N	
10 Mar 67				25#N				
25 Mar 67	1000#S	1000#S	1000#S	1000#S	1000#S	1000#S	1000#S	500#S
3 May 67		48#N	48#N			48#N		
25 Jun 67								32#N
								72#P_2O_5
26 Jun 67								10# Iron Chelate
18 Jul 67					64#N			
26 Jul 67					144#P_2O_5			
1 Aug 67		32#N	32#N	32#N				

APPENDIX I. Tabulation of Fertilizer applied to each land (January 1966 - December 1968 cont'd)

Date	Lands							
	10	11	12	13	14	15	16	17
11 Oct 67						48#N	48#N	32#N
3 Nov 67		42#N			42#N			
5 Jan 68		108#N	108#N	108#N				
27 Feb 68	64#N				64#N	64#N	64#N	32#N
11 Mar 68	72#P_2O_5				72#P_2O_5	72#P_2O_5	72#P_2O_5	72#P_2O_5
14 Mar 68								45#P_2O_5
		162#P_2O_5	162#P_2O_5	162#P_2O_5				
19 Apr 68						42#N	42#N	
5 May 68	50#N				50#N			32#N
18 Jun 68	42#N				42#N			
	36#P_2O_5				36#P_2O_5			
7 Jul 68		78#K_2O	78#K_2O					
29 Jul 68						32#N		
						72#P_2O_5		
31 Jul 68				32#N				
				72#P_2O_5				

APPENDIX I. Tabulation of Fertilizer applied to each land (January 1966 - December 1968 cont'd)

Date	Lands							
	10	11	12	13	14	15	16	17
6 Aug 68				10#Iron Chelate	10#Iron Chelate	10#Iron Chelate		
29 Aug 68				32#N		32#N		
11 Oct 68						32#N 36#P_2O_5 52#K_2O	32#N 36#P_2O_5 52#K_2O	21#N 18#P_2O_5 26#K_2O

APPENDIX II. Tabulation of Monthly Irrigation per Land (January 1966 - December 1968).

The amount of irrigation water applied per land per month was determined by dividing the total amount of water applied by 27,154 (number of gallons in an acre inch). The acre inches per land were totaled and divided by 12 to determine feet per year. There are 325,850 gallons per acre foot.

APPENDIX II. Tabulation of Monthly Irrigation per Land - 1966

LANDS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Jan	.5	.5	.5	.5	.5	.5	.5	.5	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mar	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.3	3.3	3.3	3.3	2.2	2.2	2.2	2.2
Apr	3.5	3.5	3.5	3.5	3.8	3.8	3.8	3.8	6.5	6.5	6.5	6.5	2.6	2.6	2.6	2.6
May	8.7	8.2	8.2	7.6	8.7	8.4	8.4	7.9	8.1	7.9	8.0	8.3	5.4	3.9	2.8	2.2
Jun	8.8	9.5	9.8	9.3	12.0	11.9	12.6	12.7	4.4	3.9	3.9	3.9	4.5	4.5	4.5	4.5
Jul	13.9	12.3	11.0	11.3	12.5	13.5	14.0	14.0	13.6	10.5	4.2	4.2	7.0	6.0	6.0	6.0
Aug	15.2	14.1	10.0	15.3	15.1	15.0	12.9	10.2	15.0	11.1	4.0	4.0	4.5	5.1	5.1	5.1
Sep	13.7	15.8	14.5	14.5	13.2	16.6	15.5	15.5	6.2	4.8	5.2	5.2	6.4	7.3	2.4	2.4
Oct	3.8	3.8	1.4	1.4	.8	4.1	3.7	3.7	3.2	1.4	.5	.5	2.3	2.3	3.1	1.2
Nov	2.1	2.1	2.1	2.1	2.3	3.0	3.0	3.0	.7	.7	.7	1.3	.5	1.1	1.1	.5
Dec	1.8	1.8	1.8	1.8	.3	.3	.3	.3	0	0	0	0	0	0	0	0
Total Acre Inches/ Year	75.8	75.4	66.6	71.0	85.8	80.9	78.5	75.1	61.0	50.1	36.3	37.2	35.4	35.0	29.8	26.7
Lands	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Acre Feet/ Year	6.3	6.2	5.5	5.9	7.1	6.7	6.5	6.2	5.0	4.1	3.0	3.1	2.9	2.9	2.4	2.2

APPENDIX II. Tabulation of Monthly Irrigation per Land - 1967

LANDS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb	1	1	1	1	2.0	2.0	2.0	2.0	1.4	1.5	1.5	1.5	1.5	1.4	1.4	1.4
Mar	9.8	8.2	8.2	8.2	6	6.2	6.2	6.2	3.8	1.6	1.6	1.6	1.5	1.5	1.5	1.1
Apr	1	1	1	1	1.6	1.6	1.6	1.6	3.1	2.2	2.2	2.2	5.8	5.8	5.8	5.8
May	11.6	9.4	9.4	10.7	8.2	8.2	7.1	7.4	9.0	5.5	7.5	7.0	8.0	8.5	8.5	7.4
Jun	8.5	11.9	12.9	9.9	9.5	10.6	10.2	12.8	12.6	10.0	4.9	5.7	8.1	10.0	4.4	9.1
Jul	15.0	12.0	10.0	11.0	11.0	14.0	14.0	18.0	16.0	8.0	4.0	1.0	10.0	15.0	4.0	12.0
Aug	18.0	14.0	18.0	16.0	16.0	15.0	13.0	9.0	11.0	11.0	11.0	9.0	8.0	5.0	3.0	21.0
Sep	11.0	9.0	9.0	11.0	6.0	4.0	8.0	10.0	12.0	11.0	7.0	8.0	9.0	4.0	0	7.0
Oct	8.0	4.0	9.0	8.0	11.0	11.0	8.0	8.0	9.0	11.0	11.0	9.0	9.0	8.0	7.0	12.0
Nov	3.0	4.0	4.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	4.0	3.0	3.0
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Acre Inches/ Year	86.9	74.5	82.5	80.8	75.3	75.6	73.1	78.0	80.9	64.8	52.7	48.0	63.9	63.2	39.1	80.2
Lands	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Acre Feet/ Year	7.2	6.2	6.8	6.7	6.2	6.3	6.0	6.5	6.7	5.4	4.3	4.0	5.3	5.2	3.2	6.6

APPENDIX II. Tabulation of Monthly Irrigation per Land - 1968

LANDS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1
Mar	2.0	2.0	3.0	3.0	3.0	2.0	.5	2.0	2.0	1.0	1.0	3.0	1.0	3.0	3.0	3.0
Apr	11.0	7.0	6.0	5.0	6.0	6.0	8.0	4.0	6.0	6.0	7.0	6.0	10.0	5.0	8.0	8.0
May	14.0	9.0	5.0	17.0	10.0	10.0	15.0	14.0	12.0	12.0	15.0	13.0	11.0	8.0	11.0	8.0
Jun	8.9	14.9	16.2	15.0	13.1	13.0	13.9	9.7	14.8	14.3	17.1	15.6	14.5	10.2	6.0	1.5
Jul	14.2	13.0	17.2	15.4	3.1	12.8	12.1	13.2	12.0	10.7	11.6	11.1	11.1	9.8	0	0
Aug	15.1	13.0	9.0	12.0	15.0	14.0	13.2	11.0	11.0	12.0	10.0	10.0	10.0	8.0	0	0
Sep	14.0	9.0	11.0	10.0	10.0	11.0	15.0	20.0	14.0	13.0	10.0	14.0	12.0	5.0	4.0	0
Oct	6.0	8.0	8.0	3.0	6.0	5.0	7.0	6.0	6.0	5.0	8.0	2.0	6.0	7.0	7.0	6.0
Nov	0	0	1.0	0	1.0	1.0	1.0	1.0	1.0	.5	.5	3.0	2.0	2.0	2.0	1.0
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Acre Inches/ Year	85.2	75.9	76.4	66.9	67.2	74.9	85.7	80.9	79.8	74.5	80.8	77.7	78.6	59.0	42.0	28.5
Lands	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Acre Feet/ Year	7.1	6.3	6.3	5.5	5.6	6.2	7.1	6.7	6.6	6.2	6.7	6.4	6.5	4.9	3.5	2.3

APPENDIX III. Control of Seepage from the Irrigation Reservoir of the Area 15 Experimental Farm

BACKGROUND:

The Area 15 irrigation reservoir was designed to hold approximately one million gallons of water. Construction was completed in the summer of 1964. The reservoir is of trapezoidal cross section, with an approximate surface area of 12,100 square feet (110' X 110') when filled to its normal depth of 13 feet. The porosity of the soil required sealing of the sides and bottom of the reservoir. Bentonite clay was the initial sealant selected by the REECo engineers.

The reservoir was filled in the fall of 1964. After filling, it was apparent that the reservoir leaked badly, and it was doubtful if an adequate water supply for crop irrigation could be maintained during the summer months. In the spring of 1965, the water in the reservoir was pumped out, and the sides were coated with cement grout applied over a 2-inch mesh screen. The bottom of the reservoir was not grouted because the REECo engineers felt that the thick layer of bentonite on the bottom (which had washed off the sides) had sealed it. However, the leakage losses were still apparent after the grouting. These losses gradually decreased over the next two years, but during the fall and winter of 1967 they showed a marked increase.

The water level dropped 32 inches in 15 days during December. The water level was again measured in January, and the same loss of approximately two inches per day was noted. During this period the reservoir was frozen over most of the day, and temperatures were quite low. Therefore, it is assumed that losses due to evaporation were negligible.

REECo charges $1.70 for every 1,000 gallons of water pumped at the well head. Every inch of water lost in the reservoir equals approximately 7,500 gallons and costs us $12.75. This means that water lost from seepage is doubly costly, as we have already paid for it but have not had the use of it.

The seepage loss in winter was costing us at least $25 a day. In view of these expenses, it was felt that the various seepage control methods should be investigated in order to select one that would most nearly answer our needs.

METHOD OF SEEPAGE CONTROL:

The Bureau of Reclamation engineers believe that an ideal sealant should have the following characteristics:

1. It must be nontoxic to humans, animals, and crops.

2. It must reduce leakage to 0.1 to 0.3 cubic foot of water per square foot of wetted soil area per day.

3. It must be capable of nonrestrictive application during any time of the year, under a broad range of water pH and salt content, under a broad range of soil composition, and under static or dynamic flow conditions.

4. It must resist damage by animals, equipment, erosion, and hydraulic pressures.

5. It must be durable; not deteriorated by climatic conditions, such as freezing and thawing, sunlight, wetting, and/or drying; not deteriorated by microorganisms; not deteriorated by reemulsification or chemical changes; and not deteriorated by reverse hydraulic flow; and it should be capable of resealing.

6. It must be efficient in use of material (low cost).

The Bureau knows of no material that will fill all of these requirements, at the present time. There are a number of products that will meet the majority of these characteristics.

Concrete and asphalt linings have been used for many years, but the construction costs are high. Plastic and rubber materials are slightly cheaper but have a high upkeep cost.

Bentonite clay is used as a sealer by incorporation into the soil; and as it becomes wet, it expands causing the area to seal. The clay, however, is subject to reactions with calcium ard magnesium salts in the water with the result that the clay lining deteriorates with time. This apparently occurred in our reservoir.

The previously mentioned methods of seepage control require preparation of the reservoir before the materials can be applied. The reservoir would have to be emptied, cleaned, and allowed to dry before work could commence. It would be impractical to use the plastic or rubber, as these linings must be secured by use of aggregates and the walls of the reservoir are too steep to allow this to be feasible. Also, the rough surface of the walls of the reservoir might puncture the linings after a period of time, thus making the linings ineffective as seepage control devices.

Chemical sealants are applied to the subgrades where they react chemically to form solid or semisolid gels, or deposit precipitation in the soil voids, or otherwise render the subgrade impervious to water by predominantly physical action. These chemicals can be applied directly to the water and do not require costly preapplication preparations.

A chemical sealant has to meet the following criteria to be an economical sealing agent. The sealant must be conveyed to the loss areas by the water, must be stable in the presence of the calcium and magnesium salts normally present in irrigation water, and must be easily applied.

Of all chemical sealants investigated, the one that seemed to meet these requirements best was "Soil Sealer-13 (SS-13)" distributed by Seepage Control, Inc., of Phoenix, Arizona.

SELECTION OF SOIL SEALER-13 (SS-13):

SS-13 consists of a mixture of oil-soluble resinous polymers in a carrier of common diesel fuel. When applied to soil in diluted emulsion form, these polymers by virture of their surface active properties with respect to both soil and water, increase the resistance to water flow through the soil.

A sample of 10 pounds of soil, a water sample, and copies of soil analysis reports were sent to the Seepage Control, Inc., laboratory in Phoenix, Arizona. There, they checked the compatibility of their product with our soil and water.

The following is the laboratory finding and recommendation.

> "The soil, water, and Soil Sealer-13 are all compatible. The permeability coefficient of the soil at 118 PCF was approximately 0.25 feet per day under unit gradient, and this was reduced by approximately 60 percent to less than 0.1 with a 3-day exposure to a 1:1,000 Soil Sealer-13 suspension. We would expect similar results in the field."
>
> "We would recommend two treatments with Soil Sealer-13 to achieve optimum results. The first treatment of the million-gallon reservoir with 1,000 gallons of Soil Sealer-13 should be followed a week to 10 days later by a second treatment with 400 gallons of Soil Sealer-13. Each treatment should remain in contact with the soil a minimum of 48 hours, and preferrably 72 hours."

APPLICATION OF SOIL SEALER-13:

On March 27, 1,400 gallons of Soil Sealer-13 was delivered in a tank truck by Seepage Control, Inc. Four hundred gallons was pumped into a tank trailer for storage until the material was required for the followup treatment.

A centrifugal pump mounted on the tank truck was used in the application of the material. The centrifugal pump breaks up any solidification of the material and also permits a rapid application of it. The pumping action gives a uniform mixture of SS-13 and water which flowed into the reservoir at the well discharge outlet. The turbulence created by the incoming water and the miscibility of the SS-13 resulted in rapid dispersion of the soil sealant throughout the reservoir.

The application of SS-13 was begun at 10:40 a.m. and was completed at 11:20 a.m.

During the first 24 hours following the application, the water level dropped three inches. During the following four days, there was a loss of approximately two inches each day. No water was removed from the reservoir for 120 hours following the application.

The followup application of Soil Sealer-13 was made on April 5. The 400 gallons of material were added to the reservoir by gravity flow from the tank trailer. It took approximately 2-1/2 hours to empty the tank. This solution was allowed to remain undisturbed for 75 hours before any water was pumped from the reservoir.

RESULTS OF THE CONTROL TREATMENT:

The water loss was measured over a 72-hour period between 26 and 29 April. An evaporation pan was also used so that the true seepage loss would be known. The reservoir dropped 6 inches, and the evaporation pan lost 1.75 inches. Actual seepage loss was calculated to be 4.25 inches or 1.41 inches per day. This represents a seepage reduction of approximately 30 percent. While this does not approach the Seepage Control, Inc., estimate of 60 percent reduction, it still represents a sizeable decrease in seepage loss. The company states that there is usually a gradual reduction of an additional 10 to 15 percent in the seepage rate during the first three years following application.

ECONOMICS OF THE SEEPAGE CONTROL METHOD:

The total cost of treatment was $2,450. This charge included the cost of the material, transportation, application, labor and supervision. The moneys for this service were supplied from the fees paid REECo for water pumped at the wellhead.

As stated previously, the reservoir has a surface area of 12,100 square feet (110' X 110'). Our original rate of seepage loss was in excess of two inches per day. Every six days, we lost approximately 90,000 gallons of water. This cost us at least $150 every six days ($1.70 per 1,000 gallons). Our monthly expense due to seepage was approximately $600.

SS-13 produced a 30 percent reduction in seepage loss and reduced our expenses by $180 each month. The total cost of application should be gained through savings on decreased water losses in approximately 13 months.

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4. SEELO-W for water conservation. Seepage Control, Inc. Phoenix, Arizona. December 1963.

5. Staff Industries, Inc. Vinyl liners for seepage prevention. Detroit, Michigan. January 1965.

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APPENDIX IV. Annual Forage Production

Type of Forage	1966	1967	1968
Hay Baled	None[1]	33-1/2 ton[2]	63 ton[3]
Green Chop	60 ton[4]	80 ton[5]	117 ton[6]

[1]Hay rake and baler were not purchased until 1967.

[2]Produced in four cuttings on 8-1/2 acres for an average of 4 ton per acre.

[3]Produced in four cuttings on 11-1/2 acres or 5.8 ton per acre.

[4]During 1966 there were 34 ton of alfalfa green chop produced on 8-1/2 acres for an average of 4.1 ton per acre; 12 ton of sudan green chop on 3-1/2 acres or 3.4 ton per acre; and 14 ton of rye green chop on 3 acres or 4.7 ton per acre.

[5]During 1967 there were 62 ton of alfalfa green chop from 8-1/2 acres or 7.3 ton per acre and 18 ton of rye green chop from 3 acres or 6 ton per acre.

[6]26 ton of rye green chop on 2-1/2 acres or 10.4 ton per acre and 91 ton of alfalfa green chop on 11-1/2 acres or 7.9 ton per acre.

APPENDIX V. Monthly Forage Production Listed by Lands
(Green Chop expressed in pounds. Hay expressed in ton.)

Month & Year	Forage	Land 1	Land 2	Land 3	Land 4	Land 5	Land 6	Land 7	Land 8	Land 9
Sep 1966	Green Chop	1800	4700	0	1000	0	0	0	1800	0
Oct 1966	Green Chop		750		1080				4850	
Nov 1966	Green Chop		3000							
May 1967	Green Chop							1900		
Jun 1967	Green Chop	330			6300	2400	1200	1250		
	Hay		2t	2t		2-1/4t		1-1/4t	2t	2-1/4t
Jul 1967	Green Chop	4200			9900			7200		
	Hay								2t	1-3/4t
Aug 1967	Green Chop	600		6300	7200				6300	7200
	Hay						1-1/4t	3/4t	3/4t	1/4t
Sep 1967	Green Chop		5600	5400	5400	300	2100	600		
	Hay								3/4t	
Oct 1967	Green Chop		4200	10,300						
	Hay									
Apr 1968	Green Chop	2000								

APPENDIX V. Monthly Forage Production Listed by Lands cont'd

Month & Year	Forage	Land 1	Land 2	Land 3	Land 4	Land 5	Land 6	Land 7	Land 8	Land 9
May 1968	Green Chop	5700	13,600	1600	1600					
	Hay			1-1/4t			1-1/4t	1t		
Jun 1968	Green Chop	7800						8000		
	Hay		1-1/2t	1-1/2t	1-3/4t	2-1/2t	1-1/4t	1/4t	2t	2-1/4t
Jul 1968	Green Chop	9000			1000	1000		3000	1000	
	Hay		2-1/4t	2t	1-1/4t	1-1/4t			1-1/2t	1-3/4t
Aug 1968	Green Chop	8400	3600	1500			500	500	1000	
	Hay		1-1/4t	1-1/2t	1-1/2t	1-3/4t	1-3/4t	2-1/4t	1-1/2t	1-1/2t
Sep 1968	Green Chop			2000	6450	4150	2000		3000	
	Hay						1-1/4t	1t		
Oct 1968	Green Chop	4000	8000	1000	10,000	1000	6000			
					1/2t	3/4t			1-1/4t	1-1/4t
Nov 1968	Green Chop						2000	4000	1000	

APPENDIX V. Monthly Forage Production Listed by Lands cont'd

Month & Year	Forage	Land 10	Land 11	Land 12	Land 13	Land 14	Land 15	Land 16	Land 17
Sep 1966	Green Chop	0	0	0			4500	6000	
Apr 1967	Green Chop		6600	9600					
May 1967	Green Chop	2400	7200	4900	1100	750	1900		
Jun 1967	Hay						1-1/2t		
Sep 1967	Green Chop					900			
Oct 1967	Hay	1t loose							
Apr 1968	Green Chop						11,100	16,000	4400
May 1968	Green Chop	1100	800				12,800	4000	5200
	Hay					1-1/2t			
Jun 1968	Green Chop					4000			
	Hay	2-1/4t	2t	2-3/4t	2-1/2t	1t			
Jul 1968	Green Chop	13,000	1000	2000					
	Hay		1-1/4t	1-1/2t	1-1/2t				
Aug 1968	Green Chop	5100				10,000			
	Hay		1-1/2t	1-1/2t	3/4t				

APPENDIX V. Monthly Forage Production Listed by Lands cont'd

Month & Year	Forage	Land 10	Land 11	Land 12	Land 13	Land 14	Land 15	Land 16	Land 17
Sep 1968	Green Chop Hay	2000	2000 1-1/4t	2000 1-1/4t	4800	500			
Oct 1968	Green Chop	3000							
Nov 1968	Green Chop	1000	3000	6000	1000	3000			

APPENDIX VI. Agricultural Equipment and Facilities

Equipment	Make	Model	Month and Year Acquired
Tractor	John Deere	2510	April 1966
Plow	John Deere	F225	April 1966
Mower	John Deere	39	April 1966
Subsoiler	John Deere	22A	September 1966
Harrow Spike Tooth	John Deere		September 1966
Tool Bar and Shanks	John Deere		September 1966
Fertilizer Distributor	John Deere	L.F.	October 1966
Rear Blade	John Deere	80A	March 1967
Rake Side Delivery	John Deere	350A	March 1967
Baler P.T.O.	J. I. Case	220 Twine Tie	March 1967
Fertilizer Injector*	Dragon Injector		May 1967
Tilt Trailer (Equipment)	Zieman Products	TT181	December 1967
Quonset Huts (2) Surplus			April 1968

*Fertilizer Injector is built into the irrigation system and is a permanent part of the system.

A "boom type" sprayer for the application of insecticides and herbicides was fabricated by Farm Support Section personnel.

A drag for leveling the lands after tilling operations was built by REECo and modified by FSS personnel.

APPENDIX VI. Agricultural Equipment and Facilities cont'd

Farm Support personnel and REECo modified the two Quonsets during the summer of 1968.

A concrete slab and ramp was added to the farm shop and supply room Quonset.

The other Quonset is used for storage of fertilizer, farm chemicals, tools, and less frequently used equipment.

APPENDIX VII. Iron Chelate Experiment

INTRODUCTION

High carbonate levels in soils and irrigation water are a problem throughout the arid regions of the Western United States. The carbonate and bicarbonate anions are known to complex iron and prevent its utilization by the plant. One of the most readily applicable chelates for use in the correction of bicarbonate-induced iron chlorosis is ethylenediamine di (o-hydroxyphenylacatic acid) (EDDHA). This chelate is known as Sequestrene 138 and is produced by Geigy Agricultural Chemicals of Ardsley, New York.

Sorghum vulgare var sudanense (Sudangrass) is extremely sensitive to bicarbonate in both soils and irrigation water.

Experience at the U.S.P.H.S. Area 15 Experimental Farm has indicated that carbonate-induced chlorosis is a problem in the production of Sudangrass, especially if the crop is grown consecutively without a rotation. Chlorosis was not observed in the 1965 Sudangrass crop. The chlorosis was observed after the first cutting in 1966 and became progressively more severe through the season.

Experimental Procedure. An experiment to study the response of Sudangrass to an application of iron chelate, was conducted during the summer of 1967 at the Area 15 Farm. Piper Sudan, an adapted and previously used variety was selected, and planted with a grain drill at the rate of 36 pounds per acre. The land had been winter fallowed and received liquid manure and an application of 500 pounds of flowers of sulphur. An application of 160 pounds of double superphosphate 0-45-0 (72 pounds of P_2O_5) and 160 pounds of ammonium sulfate 21-0-0 (32 pounds of N) were made two days prior to planting.

The study area was a half acre divided into six treated and five control plots with a border at each end. The size of the plots was 18 meters long and 6 meters wide.

The plots were randomized and replicated. The seed lot was divided into two lots of nine pounds each. The control lot of seed was planted first. The treated lot received 1-1/4 pounds of Geigy Sequestrene 138 Iron Chelate applied dry and worked thoroughly through the seed so that it would adhere to the seed. The seed was then placed in the seed box of the grain drill and planted. (Figure 1 shows the seeding scheme.) After planting, the crop was irrigated. Germination was good and a satisfactory stand was obtained.

Foliar Application. After the first cutting, a foliar application was applied to the plots to evaluate the use of a foliar application of chelate agents to reduce or eliminate iron chlorosis in Sudangrass. The plots were split longitudinal, one side being treated and the

opposite side left as control. The plots were randomized and replicated. (Figure 2 shows the spraying scheme.) The foliar application was made with a tractor-mounted boom sprayer. A solution was made with a wetting agent and 1-1/4 pounds of Sequestrene 138 Iron Chelate in 25 gallons of water. The solution was agitated to mix it thoroughly then applied. This rate of application is equal to five pounds of iron chelate per acre.

During the growing period one to three plant samples were taken weekly from each plot. At harvest time three samples were taken from the center of each plot using the 0.15 square meter circle thrown at random into the center of the plots.

At time of the second harvest, samples were taken from the split plots. One sample was taken from the center of the plot using the 0.15 square meter circle thrown at random into the center of the plots. The samples were brought to the laboratory in Las Vegas for analysis for Fe by X-ray spectroscopy.

The data on the iron content are not available pending analysis by X-ray spectroscopy of the samples.

RESULTS AND DISCUSSION. No significant differences in the coloration in either the treated or control plots were noted. Iron chlorosis was observed in all of the plots to some degree. It could not be determined by observation whether the chlorosis was any more severe in the control plots than it was in the treated plots. It was observed that the chlorosis was most severe where the plants received the highest concentration of irrigation water. These higher concentrations of water could account for the severe chlorosis in two ways; either by leaching of the plant nutrients or by the increasing of the carbonates from the irrigation waters. It may also be a combination of the two.

Iron chlorosis has been observed in other fields in Southern Nevada. It has been observed to be more severe in Sudangrass fields that have been in production for two or three years without a rotation. Iron chelate should have a beneficial effect on other crops that show chlorotic signs but are not as sensitive to the bicarbonates as Sorghum vulgare and Zea mays. Trials will be conducted on alfalfa, Medicago sativa to observe the effects of an iron chelate agent to control chlorosis in this crop.

Figure 1. Plot Plans for Iron Chelate Experiment

Application to Seed

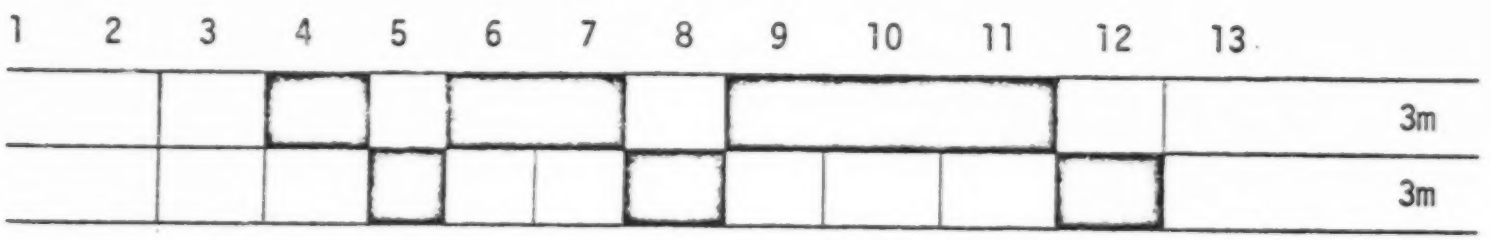
1	2	3	4	5	6	7	8	9	10	11	12	13	6m

18m

Plot No.	Treatment
1	Border
2	Treated
3	Control
4	Control
5	Treated
6	Control
7	Treated
8	Treated
9	Control
10	Treated
11	Control
12	Treated
13	Border

Total: 6 treated, 5 control, 2 borders.

Figure 2.



Split plot design. Shaded area indicated sprayed portion.